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ABSTRACT

This publication is an expanded revision of the 1960 syllabus for the State of New York and has been divided into seven major areas of subject content: Basic Electricity, Basic Electronics, Advanced Electricity option, Advanced Electronics option, Computer Circuitry option, Electrical Construction, and Electrical-Electronic Drafting. Job opportunities in industry have become so diversified that all of this subject content can no longer be taught in all schools. Options are presented that may be selected by individual schools, based on local job opportunities. Objectives of the syllabus and descriptions of the courses are included to serve as an organizational guide to local courses. A suggested scheduling arrangement is outlined for a two or three year pattern. Two columns are included: one identifying content and the other, teaching suggestions. A brief bibliography and resource directory are included. (Author/TS)

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BUREAU OF SECONDARY CURRICULUM DEVELOPMENT/ALBANY, NEW YORK 12224
1971

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technical electricity/electronics

TE OF NEW YORK/THE STATE EDUCATION DEPARTMENT
RRICULUM DEVELOPMENT/ALBANY, NEW YORK 12224
1971

SYLLABUS

in

TECHNICAL

ELECTRICITY - ELECTRONICS

The University of the State of New York/The State Education Department
Bureau of Secondary Curriculum Development/Albany/1971

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Chief, Bureau of Trade and Technical Education

FOREWORD

This publication of Technical Electricity-Electronics is an expanded revision of the 1960 syllabus. A curriculum advisory committee composed of Neil Lash, Technical and Trade Training Center, Nassau County BOCES; Arthur Lefgren, George Westinghouse Vocational and Technical High School, New York City; John Nagi, Hudson Valley Community College; and James Quinn, Brooklyn Technical High School outlined this reorganization of the syllabus.

A curriculum writing committee of Mr. Lash; Rocco Lapenta, Saunders Trade and Technical High School, Yonkers; Stanley Odre, Hutchinson Central Technical High School, Buffalo; and Lloyd Temes, Brooklyn Technical High School prepared an experimental content outline and teaching suggestions, under the guidance of Alfred Davies and Harold Wassmer, Associates, Bureau of Trade and Technical Education. Mr. Edward Kratt, Brooklyn Technical High School joined Mr. Quinn, Mr. Lash, and Mr. Lefgren in evaluating feedback and revising the final copy, which was then prepared for printing by Joseph Messier, Associate in Vocational Curriculum.

The total project was coordinated by G. Earl Hay, Supervisor of Vocational Curriculum.

Gordon E. Van Houft, *Director*
Division of School Supervision

TO THE TEACHER

This syllabus was developed on the recommendations of an advisory c technical electrical teachers.

The two-column format was suggested by the syllabus writing committ the other teaching suggestions. It is intended that the suggestions wil scope or depth that should be used in presenting the subject content and or teaching order. This aspect is to be developed by each individual te into his own local course of study.

The syllabus has been divided into major areas of subject content t State. Job opportunities in industry have become so diversified that al syllabus can no longer be taught in all schools. In view of this, the s selected by individual schools. This selection should be determined by technical electrical-electronics curriculum is being offered.

The three options of advanced electricity, advanced electronics, an in the 12th year and require two periods per day for a school year.

The subject content of this syllabus will be tested in the compreh the optional areas.

Decriptions of the courses are included to serve as an organizatio

A suggested scheduling arrangement is outlined to illustrate how th into a 2- or 3-year pattern. The basic diploma requirements for Regents guidance. When this curriculum is offered by a Board of Cooperative Edu matics, and mechanical drawing courses may be taken by the students at units in Basic Electricity, Basic Electronics, and an advanced option mu diploma requirements.

Robert H. Bielefeld, *Director*
Division of Occupational
Education Instruction

TO THE TEACHER

was developed on the recommendations of an advisory committee composed of industrialists and
l teachers.

format was suggested by the syllabus writing committee. One column identifies content and
suggestions. It is intended that the suggestions will assist teachers in identifying the
should be used in presenting the subject content and the approach or method of presentation
This aspect is to be developed by each individual teacher as he interprets the syllabus
course of study.

as been divided into major areas of subject content that are being taught throughout the
nities in industry have become so diversified that all the subject content appearing in the
ger be taught in all schools. In view of this, the syllabus presents options that may be
ual schools. This selection should be determined by job opportunities in the area where the
l-electronics curriculum is being offered.

ons of advanced electricity, advanced electronics, and computer circuitry should be taught
d require two periods per day for a school year.

ntent of this syllabus will be tested in the comprehensive technical examination including

the courses are included to serve as an organizational guide to local courses.

cheduling arrangement is outlined to illustrate how this technical curriculum can be arranged
pattern. The basic diploma requirements for Regents endorsement are also outlined for your
s curriculum is offered by a Board of Cooperative Education Services the science, mathe-
cal drawing courses may be taken by the students at the home schools. A minimum of 4 1/2
tricity, Basic Electronics, and an advanced option must be included in the Group II of the
s.

, *Director*
ional
on

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OBJECTIVES

- To provide a thorough grounding in the fundamental principles and practices of electricity and electronics.
- To provide background material sufficient for student entry into industry at a technical or semitechnical level.
- To provide a foundation in technical education from which the student, through further study, may readily advance.
- To aid the student in adapting himself to the environment of technical electricity and electronics.
- To develop by means of the broad technical studies program, an individual whose characteristics will include:
  - An established habit of basing judgments on observed and verified fact
  - An ability to apply known principles to new situations
  - A strong desire to finish assigned work
  - An appreciation of the need for cooperation and loyalty
  - An appreciation of the laws and forces of nature, and their implications
  - A regard for the importance of safety, and a habit of observing proper procedures

DESCRIPTION OF COURSES

BASIC ELECTRICITY - includes all aspects of direct and alternating cu
sulating materials, resistance, voltage, current distribution, energy
and techniques, magnetism, inductance, and capacitance in alternating
as analytical tools. The subject content is applied in student labor
tions throughout the course. Throughout all technical courses stress
laboratory reports.

BASIC ELECTRONICS - subject content includes elements of electrical c
gas tubes (diode, triode, and multielectrodes), power supply systems,
trols. Solid state physics is emphasized in order to assist students
association with other circuits. Laboratory experiments provide prac
through the use of standardized instruments.

ADVANCED ELECTRICITY - the basic power requirements of modern electri
ed through generation and distribution of three-phase power. Power m
and the instrumentation of transformers is covered through the subjec
transformers.

ADVANCED ELECTRONICS - standard procedures used in industry in the de
electronic unit are studied. The performance of an electronic systen
frequency response is analyzed. Filter coupling, peaking, feedback,
to achieve desired performance. The principles learned are applied t
circuits.

The generation and shaping of pulse and damp waves is also studi
applied in the development of TV sweep, radar, and digital circuits.

COMPUTER CIRCUITRY - various number systems including binary and octa
systems are analyzed. Problems in computer design stress Boolean al
and full-adder, shift register, and counters.

Computers are analyzed through the use of block diagrams and ty
explained through the application of the atomic theory of matter and
symbols and configurations are integrated into circuit analysis. Tr
current gain as it is effected by temperature, is stressed in circui
device, and control circuits, as well as input-output devices, is app
maintenance.

DESCRIPTION OF COURSES

cludes all aspects of direct and alternating current - the concepts of conductors, in-
sistance, voltage, current distribution, energy, work and power, measuring instruments
ism, inductance, and capacitance in alternating currents, and the uses of these concepts
The subject content is applied in student laboratory experiments and teacher demonstra-
ourse. Throughout all technical courses stress is placed upon proper format in writing

bject content includes elements of electrical circuits, characteristics of vacuum and
de, and multielectrodes), power supply systems, simple amplifiers, and industrial con-
ysics is emphasized in order to assist students in analysis of active devices and their
circuits. Laboratory experiments provide practical application of electronic concepts
ndardized instruments.

the basic power requirements of modern electrical and electronic technology as emphasiz-
and distribution of three-phase power. Power measurements in the three-phase systems
n of transformers is covered through the subject content of three-phase wye and delta

standard procedures used in industry in the design, development, and production of an
tudied. The performance of an electronic system with respect to noise, distortion, and
analyzed. Filter coupling, peaking, feedback, and push-pull circuits are developed
rformance. The principles learned are applied to AM, FM, TV control, and instrumentation

nd shaping of pulse and damp waves is also studied analytically. These principles are
pment of TV sweep, radar, and digital circuits.

various number systems including binary and octal are studied. Logic diagrams and
Problems in computer design stress Boolean algebra, as well as circuits using half-
register, and counters.

alyzed through the use of block diagrams and typical circuits. Transistor theory is
application of the atomic theory of matter and semiconductor physics. Transistor type
tions are integrated into circuit analysis. Transistor stabilization, in regard to
effected by temperature, is stressed in circuit design. The theory of logic, memory
ircuits, as well as input-output devices, is applied through experiments in computer

ELECTRICAL-ELECTRONIC DRAFTING - can be introduced at the home school throu that stresses orthographic projection. The Area Center can build on this b electronic symbols and conventions. Schematic layout diagrams are used to required laboratory experiments. Emphasis is placed upon development of th of electrical and electronic equipment.

ELECTRICAL CONSTRUCTION - tools and techniques of the electrical and electr experimental models directly related to student experiments. Safety and sa all student activity.

Suggested Scheduling of Technical Electricity and

Two-Year Program

10th	11th
English 10	English 11
Social Studies	Social Studies
Mathematics 10	Mathematics 11
Mechanical Drawing	Chemistry or Physics
	Basic Electricity and Electronics — 3 periods

Three-Year Program

10th	11th
English 10	English 11
Social Studies	Social Studies
Mathematics 10	Mathematics 11
Mechanical Drawing	Chemistry or Physics
Basic Electricity — 2 periods	Basic Electronics — 2 periods

TRONIC DRAFTING - can be introduced at the home school through a standard mechanical drawing course rthographic projection. The Area Center can build on this background by teaching block diagrams and ols and conventions. Schematic layout diagrams are used to explain electrical-electronic theory in tory experiments. Emphasis is placed upon development of the working drawings needed in manufacture nd electronic equipment.

TRUCTION - tools and techniques of the electrical and electronic industry are used in constructing dels directly related to student experiments. Safety and safe procedures are an integral part of ivity.

Suggested Scheduling of Technical Electricity and Electronics

Two-Year Program

	11th	12th
ies	English 11	English 12
10	Social Studies	Physics or chemistry
Drawing	Mathematics 11	Health
	Chemistry or Physics	Basic Electronics and
	Basic Electricity and	Advanced Option — 3 periods
	Electronics — 3 periods	

Three-Year Program

	11th	12th
ies	English 11	English 12
10	Social Studies	Physics or Chemistry
Drawing	Mathematics 11	Health
ricity — 2 periods	Chemistry or Physics	Advanced Option — 2 periods
	Basic Electronics — 2 periods	

ELECTRICITY AND ELECTRONICS

Requirements for Regents Endorsement of a State or Local High School Diploma

Group I: Required Constants	Units
English	4
Social Studies (including 1 year of American History)	3
Science	1
Mathematics	1
Health	½
Total	9 ½

Group II: Required Technical Subjects	
Basic Electricity	1 ½
Basic Electronics	1 ½
Advanced Electricity, Advanced Electronics, or Computer Circuitry	1 ½
*Mechanical Drawing Involving Electrical Concepts	½
*Physics	1
*Mathematics 10	1
Total	7

Group III: Elective Subjects	
*Mathematics 11 (Recommended)	1
Open Elective	½
Total	1 ½

A minimum of 18 units is required for Regents endorsement of a State or local high school diploma.

* May be taught in home school.

BASIC ELECTRICITY

I.	Theory of Current Flow	2
II.	Circuits	3
III.	Measurements, Standards, and Tolerances	3
IV.	Conductors	4
V.	Magnetism	5
VI.	Electromagnetic Induction	6
VII.	Motor Action	6
VIII.	Overload Protection	7
IX.	Alternating Current	7
X.	Single-Phase Circuits	9
XI.	Basic Instruments	10
XII.	DC Generators	11
XIII.	DC Motors	11
XIV.	Three-Phase System	11
XV.	Alternators	12
XVI.	Transformer Principles	12
XVII.	Alternating Current Motors	12
XVIII.	Grounding	12
XIX.	Batteries	13

I. Theory of current flow

A. Construction of atom —— electron flow — Con
b

B. Law of action between charges — Dis

C. Concepts of voltage, current, and resistance — Def
Def
Def
Men

D. Conductors, semiconductors, and insulators — Dis
i

E. Sources of e.m.f. — Dis

1. Electromagnetic induction
2. Chemical
3. Thermal
4. Piezoelectric
5. Photovoltaic
6. Static
7. Other

Note: Topics labeled *General Treatment* are to be covered
prehensive examination.

Both theory and laboratory instruction is required

BASIC ELECTRICITY

current flow	
tion of atom —— electron flow	Concept of simple atoms. Discuss valence and conduction bands.
ction between charges	Discuss law of charges and electrostatic field concept.
of voltage, current, and ance	Define voltage as a difference of potential. Define current as a flow of electrons. Define resistance as the opposition to current flow. Mention units of current, voltage, and resistance.
rs, semiconductors, and tors	Discuss the nature of conductors, semiconductors, and insulators. List examples.
of e.m.f.	Discuss qualitatively the various sources of e.m.f.

tromagnetic induction
ical
mal
oelectric
ovoltaic
ic
r

abeled *General Treatment* are to be covered in class but shall not be tested on the com-
sive examination.

ory and laboratory instruction is required.

II. Circuits	
A. Ohm's law	Discuss Ohm's la
B. Series	State the princi give illustrat
C. Parallel	
D. Series/parallel	Solve problems i circuits.
E. Kirchhoff's current and voltage laws	Make statement c
III. Measurements, standards, and tolerances	
A. Current	
1. Ammeter	Show how ammete precautions i
2. Shunt calculations	
B. Voltage	
1. Voltmeter	Show how a voltm
2. Multiplier calculations	Calculations of
3. Meter sensitivity and loading	Quantitative tr
C. Resistance	
1. Voltmeter-ammeter method	Demonstrate resi Emphasize that properly locat

	Discuss Ohm's law. Solve problems.
	State the principles of series and parallel circuits and give illustrated examples.
	Solve problems involving combinations of series/parallel circuits.
nt and	Make statement of laws with simple, illustrated examples.
ards, and	
	Show how ammeter is connected in a circuit. Explain precautions in using an ammeter.
ons	
	Show how a voltmeter is used in a circuit.
culations	Calculations of sensitivity required.
ty and loading	Quantitative treatment of voltmeter loading is required.
ter method	Demonstrate resistance measurement by the V-A method. Emphasize that accurate resistance readings depend on properly locating the meters in the circuit.

2. Ohmmeter	Discuss the sim required.
a. Uses	Discuss precaut
b. Circuitry	
3. Wheatstone bridge	Discuss the the several of it accuracy. We
D. Power	Define power.
1. Units —— watts to horsepower	State that powe the voltage a
2. Voltmeter-ammeter method	Using Ohm's Law $W=I^2R$ and $W=\frac{E^2}{R}$
3. Wattmeter	Discuss the met
E. Energy	Define electric multiplied by
IV. Conductors	
A. Factors affecting resistance	Discuss the eff cross-section constant.
B. Resistivity	Solve problems
C. Wire size a. Permissible voltage drops	Line drop calcu Underwriter's also be made

DUCATION

Discuss the simple series ohmmeter. Calculations are required.
Discuss precautions in use of the ohmmeter.

ry

e bridge

Discuss the theory of the Wheatstone Bridge. Describe several of its applications and discuss its superior accuracy. Work simple problems with formula.

Define power. Convert watts to horsepower.

- watts to horsepower

State that power can be determined from the product of the voltage across, and the current through, a circuit.

-ammeter method

Using Ohm's Law show that power can be expressed as

$W=I^2R$ and $W=\frac{E^2}{R}$

Discuss the method of connecting a wattmeter in a circuit.

Define electrical energy. Explain that energy is power multiplied by time. Specify energy unit (Kilowatthours).

fecting resistance

Discuss the effect of material composition, length, and cross-sectional area on resistance, temperature being constant.

Solve problems using $R = \frac{KL}{d^2}$

le voltage drops

Line drop calculations should use National Board of Fire Underwriter's standards. However, reference should also be made to local ordinances as required.

b. Use of wire size	Use wire tab conductors meter.
c. Calculation of wire size	Determine mi which will tables to
D. Temperature effect calculations	Calculate th General tr efficient
V. Magnetism	
A. Permanent magnets	Discuss the fields.
1. Properties	
a. Laws of interaction b. Lines of force c. Permeability and saturation	
2. Molecular Theory	Use simple m uration, r Discuss ma
3. Materials	Describe dis and parama
B. Electromagnets	
1. Direction and distribution of magnetic fields about current carrying conductors and coils	Discuss magn and with c coil.

of wire size	Use wire tables as sources of information about electrical conductors. Demonstrate use of wire gauge and micrometer.
ulation of wire size	Determine minimum circular mil area of copper conductor which will satisfy line drop specifications. Use wire tables to select available wire size.
rature effect calculations	Calculate the effect of temperature on resistance. General treatment of materials having a negative coefficient of resistivity.
sm	
nent magnets	Discuss the basic concepts of magnetism and magnetic fields.
perties	
aws of interaction ines of force ermeability and saturation	
ecular Theory	Use simple molecular theory to explain permeability, saturation, residual magnetism, permanent magnets. Discuss magnetizing, demagnetizing, and shielding.
erials	Describe distinction between ferromagnetic, diamagnetic, and paramagnetic materials.
romagnets	
ection and distribution of agnetic fields about current arrying conductors and coils	Discuss magnetic fields associated with straight conductor and with coil. Use current rules for straight wire and coil.

2. Factors affecting strength	
a. Ampere turns	Discuss eff current,
b. Permeability	Define perm
VI. Electromagnetic induction	
A. Faraday's law	Point out induced
B. Lenz's law	Discuss th
C. Induction coils	
1. Self-induction	Define sel it.
2. Mutual-induction	Define mut affect i
D. Inductance	Discuss in turns, c
E. Voltage of induction	The voltag of the i
VII. Motor action	
A. Principle of operation	
1. Force on a conductor	Discuss th electrom

EDUCATION

affecting strength	
turns	Discuss effect on magnet strength of varying the turns, current, and core material.
bility	Define permeability.
ic induction	
law	Point out the factors which determine the magnitude of induced e.m.f.
	Discuss the polarity of induced self-e.m.f.
coils	
uction	Define self-induction and discuss the factors which affect it.
nduction	Define mutual-induction and discuss the factors which affect it. Mention some applications.
	Discuss inductance qualitatively in terms of number of turns, core permeability, and core shape.
induction	The voltage across the inductance depends on the magnitude of the inductance and the rate of change of current.
of operation	
a conductor	Discuss the force on a conductor carrying a current in an electromagnetic field.

2. Relative directions

Show the magn
current, he
Hand Motor
current-car

B. Applications

1. DC motors

Introduce co
reinforced

2. D'Arsonval meter movement

Describe how
precision s
inherently

VIII. Overload protection

A. Fuse

Give general
fuses, ind
briefly ti

B. Circuit breaker

Introduce th
circuit br
uses in pr

IX. Alternating current

A. Basic concepts

1. Sine wave development

Discuss and
press the

2. Frequency

Define frequ
and period

3. Maximum value

Define maxim

ections	Show the magnetic field formation of a conductor carrying current, held in a magnetic field. Explain the Left Hand Motor Rule to show the direction of motion of a current-carrying conductor in a magnetic field.
	Introduce concept of counter e.m.f. at this point, to be reinforced at a later date.
eter movement	Describe how force on a conductor acts against a pair of precision springs. Mention that this type of meter is inherently an average-reading device.
ion	Give general description of low-voltage plug and cartridge fuses, indicating voltage and current ranges. Discuss briefly time-delay fuses, both plug and cartridge types.
r	Introduce the general idea of thermal and electromagnetic circuit breakers, including principle of operation, and uses in preference to fuses.
nt	
velopment	Discuss and illustrate the generation of a sine wave. Express the function in terms of both degrees and radians.
	Define frequency and periodic function. Relate frequency and period.
ue	Define maximum and peak-to-peak values.

4.	Effective value	Define effec effect. D maximum va
5.	Average value	Define avera
6.	Instantaneous value	Define insta
7.	Effective resistance	Discuss the resistance
8.	Power (watts)	Define power factor.
9.	Reactive volt-amperes (vars)	Define react reactive c
10.	Volt-amperes (va)	Define as th
11.	Power factor	Define power volt-amper the phase
B.	Inductive circuits	
1.	Calculation of inductive reactance	State that i to current
2.	Phase relationships	Discuss the phase lag circuit.
3.	Mutual inductance	Discuss coef

DUCATION

value	Define effective value (R.M.S.) in terms of heating effect. Describe the relationship between effective and maximum values for sine waves.
alue	Define average value. Illustrate for sine wave.
eous value	Define instantaneous value and illustrate with problems.
resistance	Discuss the difference between DC resistance and effective resistance.
tts)	Define power as the product of voltage, current, and power factor.
volt-amperes (vars)	Define reactive power as the product of voltage and the reactive component of the current.
res (va)	Define as the product of volts and amperes.
tor	Define power factor as the relationship between watts and volt-amperes. Relate the power factor to the cosine of the phase angle of the circuit.
ircuits	
on of inductive reactance	State that inductive reactance represents the opposition to current flow in a circuit.
ationships	Discuss the concept of phase relationship. Explain the phase lag of current behind voltage in an inductive circuit.
ductance	Discuss coefficient of coupling.

C. Capacitive Circuits

1. Basic concepts

2. Factors affecting capacitance

3. Voltage across a capacitor

4. Calculation of capacitive reactance

5. Phase relationships

X. Single-phase circuits

A. Series circuits involving R, L, and C

1. Voltage, current, and power calculations

2. Phasor diagrams

e Circuits	
oncepts	Explain capacitance in terms of: . the opposition to voltage change . the storage of charge Define capacitor. Discuss action of capacitor charging and discharging.
affecting capacitance	Discuss qualitatively the dependence of capacitance on the physical construction of the unit. Consider the effect of connecting capacitors in series and in parallel.
across a capacitor	Explain that the voltage across a capacitor varies directly as the charge and inversely as the capacitance.
tion of capacitive reactance	State that capacitive reactance represents the opposition offered to current flow by a capacitor in a circuit.
elationships	Discuss the effect of capacitance on the phase relationship between circuit voltage and current.
e circuits	
rcuits involving R, L, and C	
, current, and power lations	Introduce the concept of impedance as the total circuit opposition to current flow. Present both analytical and graphical solution for impedance (phasor diagram). Thoroughly develop the concepts of power, voltamperes, reactive voltamperes, and power factor.
diagrams	Develop phasor diagrams both for impedance and for voltage.

B. Parallel circuits involving R, L, and C	
1. Voltage, current, and power calculations	Consider pure compo only single eleme current, voltage,
2. Phasor diagrams	Develop phasor diag
C. Resonance	
1. Series	Define series reson series resonant c current, versus f
2. Parallel	Define parallel res parallel resonant current, versus f
D. R-C time constants	Discuss the rise a across, all compo voltage is applie
XI. Basic instruments	
A. D'Arsonval	Discuss constructi Note applications desired, measure
B. D'Arsonval with rectifier	
C. Iron vane	
D. Electrodynamometer	

DUCATION

rcuits involving R, L, and C

current, and power tions	Consider pure components only, and branches containing only single elements. Calculations of impedance, current, voltage, power, and power factor required.
agrams	Develop phasor diagrams for current.
	Define series resonance. Discuss characteristics of series resonant circuits and curves of impedance and current, versus frequency.
	Define parallel resonance. Discuss characteristics of parallel resonant circuits and curves of impedance and current, versus frequency.
nstants	Discuss the rise and decay of current through, and voltage across, all components in basic R-C circuits to which a voltage is applied.
ents	Discuss construction and basic operation of instruments. Note applications, considering relative precision desired, measured frequency, and sensitivity.
with rectifier	
mometer	

E. Use of —	Stress use rather t accuracy, frequen
1. Watthour meter	
2. Oscilloscope	
3. Frequency meter	
4. VOM	
5. VTVM	
6. Digital readout meters	
XII. DC generators	
A. Construction and basic theory	Describe armature c underlying the ge
1. Separately excited	armature. Consid
2. Self-excited (shunt)	
B. Voltage control	Discuss method for generators.
XIII. DC motors	
A. Theory	Discuss the basic c torque in DC moto electromotive for
B. Characteristics	Discuss the operati and shunt motors. of rotation.
XIV. Three-phase systems	
A. Voltage, current, and power	Discuss the advanta current and volta
1. Wye	
2. Delta	

	Stress use rather than theory of operation. Consider accuracy, frequency response, and loading effect.
ter e eter	
dout meters	
and basic theory excited d (shunt)	Describe armature construction and the basic concepts underlying the generation of a voltage in the armature. Consider the action of the commutator.
ol	Discuss method for controlling the terminal voltage of DC generators.
	Discuss the basic concepts underlying the development of torque in DC motor. Consider the generation of a counter electromotive force.
cs	Discuss the operating characteristics of the DC series and shunt motors. Discuss methods of reversing direction of rotation.
ems ent, and power	Discuss the advantages of polyphase systems. Show the current and voltage relationships in both connections.

B. Three-phase, four-wire transmission and distribution system	Discuss and tr
XV. Alternators	
General principles of operation (general treatment)	Discuss freque
XVI. Transformer principles	
A. Transformer action	Discuss output
B. Current and voltage	Define t direct are in
C. Special types: the autotransformer	Discuss diagra in bot
XVII. Alternating current motors	
A. Three-phase induction	Briefly
B. Single-phase	Demonst unive and s
XVIII. Grounding	Discuss elect possi Consi

AL EDUCATION

hase, four-wire transmission stribution system	Discuss this type connection as applied to generators and transformers.
ciples of operation reatment)	Discuss the generation of e.m.f. and show the effects on frequency of the speed and number of poles.
principles	
rmer action	Discuss how the power input adjusts to changes in power output.
and voltage	Define the term volt/turn. Explain that the voltages are directly proportional to turns ratio, and that currents are inversely proportional to the turns ratio.
types: the ransformer	Discuss construction and basic principles. Include diagrams illustrating current distribution and voltages in both step-up and step-down connections.
current motors	
hase induction	Briefly discuss the general principle of operation.
phase	Demonstrate the discuss briefly the common types: universal, split-phase, shaded-pole, capacitor-start, and synchronous.
	Discuss grounding as a safety and protective feature in electrical circuits. Consider methods for minimizing possible injury when working in electrical circuits. Consider use of ground as a point of reference.

XIX. Batteries (general treatment)	Demonstrate fac dissimilar me
A. Types	Display differe mercuric oxid binations of Display common lead/acid).
B. Characteristics and care	Compare batteri lyte, charge Demonstrate a safety consid batteries. C and its amper

(general treatment)

Demonstrate factors necessary for simple voltaic action — dissimilar metals and electrolyte.

Display different sizes of common dry cells (carbon/zinc, mercuric oxide/zinc). Discuss series and parallel combinations of cells.

Display common storage cells (nickel/iron, nickel/cadmium, lead/acid).

ristics and care

Compare batteries as to applications, cell voltage, electrolyte, charge and discharge rates, and general maintenance. Demonstrate and discuss the care, maintenance, and safety considerations in the use of lead/acid storage batteries. Consider the internal resistance of a cell, and its ampere-hour rating.

BASIC ELECTRONICS

I. Basic Rectification Circuits 16

II. Basic Amplification Circuits 17

III. Electronic Systems 23

I. Basic rectification circuits	
A. Vacuum diode	
1. Thermionic emission	Discuss heat requ
2. Photoelectric emission	General treatment
3. Plate characteristic	Show plate curren linearity and s
4. Diode static resistance	Graphical determi
5. Diode load and load line	Construction of t slope method.
6. Equivalent circuit	The diode can be
7. Application as a half-wave rectifier	Determination of
B. Semiconductor diode	
1. Intrinsic semiconductor	Define a semicond of temperature the effect of t thermistor.
2. Doped semiconductor	Discuss the need Introduce the d type materials.
3. P-N junction	Discuss the forma formation of th potential barri

n circuits	
ssion	Discuss heat required for emission.
emission	General treatment.
ristic	Show plate current vs plate voltage curves. Discuss non-linearity and saturation.
esistance	Graphical determination.
load line	Construction of the load line using the intercept and slope method.
cuit	The diode can be represented by a switch and a resistance.
a half-wave rectifier	Determination of the load, peak, average, and PIV voltages.
ode	
conductor	Define a semiconductor. Illustrate graphically the effect of temperature on pure silicon and germanium. Discuss the effect of temperature on the resistance of a thermistor.
uctor	Discuss the need for conduction at room temperature. Introduce the donor and acceptor to create N and P type materials. Discuss holes and electrons.
	Discuss the formation of a junction diode. Explain the formation of the depletion region and the resulting potential barrier.

4. Diode characteristic curve	Discuss the effect of duction. Develop t Discuss leakage cu the zener diode.
5. Equivalent circuit	The junction diode ca series with a swit
6. Application as a half-wave rectifier	Determination of DC AC voltmeter and b
II. Basic amplification circuits	
A. Triode vacuum tubes	
1. Grid control	Discuss the effect o
2. Characteristic curves	General discussion o current including need for a family
3. Concept of small signal amplification	The analysis of the at the grid.
a. Dynamic plate resistance	The dynamic plate re slope of the chara
b. Amplification factor	
c. Voltage amplification	Graphical determinat characteristic cur
d. Voltage source concept	Introduce the triode series with the pl

acteristic curve	Discuss the effect of forward and reverse bias on conduction. Develop the volt-ampere characteristic. Discuss leakage current and voltage breakdown. Mention the zener diode.
circuit	The junction diode can be idealized as a battery in series with a switch.
n as a half-wave rectifier	Determination of DC output voltage. Application to an AC voltmeter and battery charger.
ation circuits	
m tubes	
ol	Discuss the effect of the grid on electron flow.
stic curves	General discussion of the effect of grid voltage on plate current including cutoff and saturation. Discuss the need for a family of plate characteristics.
small signal amplification	The analysis of the effect of small DC voltage changes at the grid.
plate resistance	The dynamic plate resistance is the reciprocal of the slope of the characteristic curve.
ation factor	
amplification	Graphical determination of voltage gain using plate characteristic curves.
source concept	Introduce the triode as a constant voltage source in series with the plate resistance.

e. Equivalent circuit	Develop t alent c
f. Application	Thermist
4. Amplification of an AC signal	
a. Dynamic transfer characteristic	Construct the pl point
b. Cathode bias	Computat pass c
c. Signal wave forms	Graphica
d. Small vs. large signal amplification	Discuss signal large and di
e. Application	Use of t sistor
	Analysis voltag . . .
	Discuss maxim
B. Pentode vacuum tubes	Develop curre

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valent circuit	Develop the gain formula from the analysis of the equivalent circuit $A = \frac{M_u R_L}{r_p + R_L}$.
ication	Thermistor and triode amplifier as a heat sensing device.
ication of an AC signal	
mic transfer characteristic	Construction of the dynamic transfer characteristic from the plate characteristic. Selection of an operating point from the plate characteristic.
ode bias	Computation for the cathode resistor. Introduce the bypass capacitor to eliminate degeneration.
al wave forms	Graphical determination of gain using sine wave signals.
l vs. large signal amplification	Discuss the use of the equivalent circuit for small signal applications and the characteristic curves for large signal applications. Cite the need for linearity and discuss factors involved.
ication	Use of the triode as an audio amplifier with simple resistor load.
	Analysis and synthesis of circuits with a given supply voltage. Limit application to: • Maximum gain with small signal • Maximum large signal voltage output • Maximum signal power output
	Discuss and apply safe operating limits. Construct the maximum power dissipation curve.
vacuum tubes	Develop pentode out of limitations of the triode. Stress current source.

1. Screen grid	Briefly discuss p screen grid.
2. Suppressor	Briefly discuss s suppressor gri
3. Plate characteristics	Using characteris independent of
4. Transconductance	Use characterist in output curr
5. Current source	Develop the equi stant current tance. Calcul that output si $g_m E_g$.
6. AC amplification	Using load line, proportional t
7. Small signal equivalent circuit	Develop the comp rent source g_m
C. Transistors	Develop the tran of the common amplifier. Di
1. Transistor construction	Describe the con type transisto doping, barrie changes.

d	Briefly discuss plate degeneration and the need for the screen grid.
	Briefly discuss secondary emission and the need for the suppressor grid.
racteristics	Using characteristic curves show the plate current is independent of E_b.
uctance	Use characteristic to show transconductance as the change in output current per volt of input. Develop $u = g_m r_p$.
ource	Develop the equivalent circuit of the pentode as a constant current source in parallel with the plate resistance. Calculate r_p from plate characteristic. Show that output signal current is practically constant at $g_m E_g$.
cation	Using load line, graphically show that output voltage is proportional to R_L ($E_p = g_m E_g R_L$).
nal equivalent circuit	Develop the complete amplifier circuit as a constant current source $g_m E_g$ in parallel with r_p and R_L.
	Develop the transistor as a current source, with the aid of the common base circuit. Stress common emitter-amplifier. Discuss the common collector configuration.
r construction	Describe the construction of the NPN and the PNP junction type transistors. Discuss the emitter, base, collector, doping, barrier potential, and effect of temperature changes.

2. Common base amplifier

   a. Transistor action

   b. Transistor currents

   c. Transistor alpha

   d. Collector characteristics

   e. Equivalent circuit
      (hybrid model)

   f. Current and voltage gain

   g. Applications

3. Common emitter amplifier

   a. Current gain

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ıse amplifier	
stor action	Transistor action requires current. Discuss input resistance.
stor currents	The emitter current divides between the base and the collector.
stor alpha	Define alpha as the comparison of the output signal current to the input signal current using the common base configuration. Alpha is the ratio of the change of collector current to the change of emitter current. (Note: Alpha is approximately the ratio of the collector to the emitter current.)
tor characteristics	Analyze as a constant current source with high collector impedance.
lent circuit rid model)	Develop input circuit as a voltage signal source in series with the input resistance h_ib (note the low orders of magnitude of h_ib).
t and voltage gain	Trace signal currents and voltages through the equivalent circuit. Compute output signal current and voltage, and current and voltage gains.
ations	Used as a constant current source in transistor characteristic measurements.
mitter amplifier	Develop the common emitter amplifier out of the common base amplifier so as to realize a current gain greater than one.
t gain	Define Beta as the ratio of the output signal current to the input signal current $h_{ie} = \frac{\Delta V_{be}}{\Delta I_b}$.

b. Collector characteristics	Discuss how the co base current and Discuss transisto lector resistanc imately Beta mult the common base
c. Input characteristic	Develop input chara PN junction chara dynamic input re Beta =
d. Large signal amplification	
1. Fixed bias	Selection of an op istic. Determin tion of a load l
2. Signal waveforms	Graphical determin input current, s put voltage for partial cancella
3. Gain	Calculation of cur
4. Gain in decibels	Define decibel cha is a 10 t 1 pow power at two poi equal or same im

lector characteristics

Discuss how the collector current varies with changes in base current and collector voltage. Define saturation. Discuss transistor action. Note that the common collector resistance and leakage current are both approximately Beta multiplied by the corresponding value in the common base configuration.

ut characteristic

Develop input characteristic out of the forward biased PN junction characteristic. Graphically determine the dynamic input resistance.

$$\text{Beta} = \left.\frac{\Delta I_c}{\Delta I_b}\right|_{V_{CE} = K}$$

Compare the magnitude of $h_i e$ with the common base equivalent $h_i b$.

rge signal amplification

ixed bias

Selection of an operating point on an input characteristic. Determination of a bias resistor. Construction of a load line.

ignal waveforms

Graphical determination of the peak values of the signal input current, signal output current, and the peak output voltage for a given input signal voltage. Observe partial cancellation of distortion.

ain

Calculation of current, voltage, and power gain.

ain in decibels

Define decibel change as a power comparison where 1 bel is a 10 to 1 power ratio. Compute db change given the power at two points in a system, or two voltages across equal or same impedance.

5. Applications	Design of an amplifier f given load resistance
	Design of an amplifier f ing determination of l
e. Small signal equivalent circuit (hybrid model)	Develop a complete equiv ing signal source, tra simple resistor load. currents from source current, voltage, and
4. Common collector	Develop as an impedance amplifier.
a. Input and output impedances	Discuss qualitatively t low output impedances
b. Gain	Compare current, voltag CE configuration.
c. Application	Discuss use as a power without phase inversi device.
d. Field effect transistor	Develop as a device tha vacuum tube and trans
1. Construction	Develop a simple junct and gate.
2. Pinch off	Discuss formation of d junction and its eff
3. Drain current characteristics	Develop a family of dr the drain current as voltage, and gate-to

ION	
s	Design of an amplifier for maximum output voltage with a given load resistance and collector supply voltage. Design of an amplifier for maximum power output including determination of load resistance.
equivalent circuit del)	Develop a complete equivalent amplifier circuit, including signal source, transistor hybrid equivalent, and simple resistor load. Trace signal voltages and currents from source to load. Compute output signal current, voltage, and power gains.
or	Develop as an impedance transformer and as a current amplifier.
tput impedances	Discuss qualitatively the reasons for the high input and low output impedances. Compare current, voltage, and power gain with the CB and CE configuration. Discuss use as a power amplifier to provide current gain without phase inversion, and as an impedance matching device.
transistor	Develop as a device that combines the advantages of both vacuum tube and transistor amplifiers.
ion	Develop a simple junction FET. Define source, drain, and gate. Discuss formation of depletion region due to reverse bias junction and its effect on drain-to-source resistance.
rent characteristics	Develop a family of drain current characteristics showing the drain current as a function of drain-to-source voltage, and gate-to-source voltage.

4. Application	Input circuits requ
III. Electronic systems	Develop electronic with emphasis on procedures used
A. Power supplies	
1. Output voltage	
a. Circuit with resistance load	Analyze half-wave, determine the vo
b. DC load voltages	Determine the DC o average of the v ward voltage for voltage silicon
c. Silicon-controlled rectifiers	Develop the SCR as Discuss the func voltage control.
2. Peak reverse voltage	Determine the PIV
3. Ripple reduction	
a. Capacitor discharge curve	Discuss the effect
b. Ripple voltage	Discuss factors af ripple frequency
c. Applications	Determine approxim wave power suppl
d. Choke filter	The output voltag Discuss the acti

tion	Input circuits requiring high impedance.
ems	Develop electronic systems utilizing the basic circuits with emphasis on system performance and industrial procedures used in their design and realization.
s	
age	
ith resistance load	Analyze half-wave, full-wave, and bridge circuits to determine the voltage waveform across the load.
oltages	Determine the DC output voltage across the load as the average of the voltage waveform. Include diode forward voltage for vacuum tube rectifiers and for low voltage silicon rectifiers.
controlled rectifiers	Develop the SCR as a three-junction semiconductor device. Discuss the function of the gate to provide output voltage control.
se voltage	Determine the PIV for all three circuits.
uction	
r discharge curve	Discuss the effect of the RC time constant on the voltage.
oltage	Discuss factors affecting ripple voltage. Determine ripple frequency.
ions	Determine approximate output voltage for half- and full-wave power supplies using a simple capacitor filter.
lter	The output voltage is the average of the rectified wave. Discuss the action of the choke in reducing the ripple.

e. Pi section fiiters	Discuss
4. Regulation	
a. Concept of regulation	Discuss or so
b. Zener diode characteristics	Discuss chara rated curre
c. Zener diode as a regulator	Compute only.
d. Transistor regulation circuits	Current
5. Applications	Design to re diode
	Selecti a spe
B. Voltage amplifiers (common emitter)	Emphasi manne ampli
1. Transistor amplifier stability	Discuss colle
a. Temperature sensitive factors	Discuss base- of th

N	
ters	Discuss generally (general treatment).
ulation	Discuss the effect of changes of line voltage, and load or source impedance on the output voltage.
aracteristics	Discuss the practical aspects of the reverse conduction characteristic of a zener diode including zener voltage, rated power dissipation, maximum current, minimum current, and dynamic resistance.
a regulator	Compute size of limiting resistor for load variations only.
ulation circuits	Current and voltage regulation (general treatment).
	Design of half-wave, full-wave, and bridge power supplies to realize a specified output voltage. Selection of diodes to meet PIV and current requirements.
	Selection of a capacitor (general treatment) to realize a specified allowable ripple.
(common emitter)	Emphasize the common emitter amplifier. In a general manner, apply the principles developed to vacuum tube amplifiers.
fier stability	Discuss the effect of temperature change on transistor collector characteristics and on bias stability.
nsitive factors	Discuss individually the effect of temperature rise on base-emitter voltage and leakage current and the effect of these changes on the position of the quiescent point.

b. Base-emitter voltage compensation (swamping resistor)	Discuss the introducti to swamp internal r variations. Discuss (general treat tors in temperature
c. Voltage divider bias	Develop voltage divid
d. Leakage current and stability factor	Define stability fact collector current t cause of temperatur Develop (general trea is from one to Beta the stability facto to-ground biasing r resistor.
e. Application	Design a practical vo
2. Frequency response	
a. RC coupling circuit transfer function	Apply the principle t input signal voltag input impedance. D frequency using the low frequency cutof total series resist Determine the db lo for several decades Develop the negligibi frequencies 10 time

voltage compensation esistor)	Discuss the introduction of an external emitter resistor to swamp internal resistance changes due to temperature variations. Discuss (general treatment) the use of diodes and thermistors in temperature compensation circuits.
er bias	Develop voltage divider bias to stabilize operating point.
nt and stability	Define stability factor as the ratio of the change of collector current to the change of leakage current because of temperature variations. Develop (general treatment) that the range of stability is from one to Beta-plus-one. For normal operation the stability factor is equal to the ratio of the base-to-ground biasing resistor to the external emitter resistor. Design a practical voltage divider biasing circuit.
onse	
circuit transfer	Apply the principle that the output signal voltage is to input signal voltage as the output impedance is to the input impedance. Devise and plot db change against frequency using the log scale for frequency. Define low frequency cutoff as the break frequency where the total series resistance equals the capacitive reactance. Determine the db loss at cutoff. Determine the response for several decades above and below cutoff. Develop the negligibility of capacitive reactance at frequencies 10 times greater than cutoff.

		(General treatme tional to the capacitor for frequency cut
		(General treatme for a single coupling circu
b.	Low frequency response of CE transistor amplifier	Determine the t when a signal amplifier fee the low frequ treatment) lo
c.	Miller effect	Calculate the M sistor capaci
d.	High frequency response of CE transistor amplifier	Define high fre total shunt c allel combina calculations Plot the high
e.	Emitter bypass capacitor	Discuss general can be made t Indicate that reflected thr
f.	Vacuum tube	Generally apply triode and th Miller capaci
g.	Decoupling	Discuss qualita

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	(General treatment) Note that the response is proportional to the capacitive reactance of the coupling capacitor for frequencies less than 1/10th the low frequency cutoff.
	(General treatment) Plot the frequency response curve for a single circuit, or for *two* identical but isolated coupling circuits.
frequency response of CE ansistor amplifier	Determine the total resistance for an RC coupling circuit when a signal source feeds a CE amplifier, and when an amplifier feeds another identical amplifier. Determine the low frequency cutoff. Plot the overall (general treatment) low frequency response.
er effect	Calculate the Miller effect capacitance, given the transistor capacitances and the gain of the stage.
frequency response of CE ansistor amplifier	Define high frequency cutoff as the frequency where the total shunt capacitive reactance is equal to the parallel combination of all shunting resistances. Limit calculations to that between two cascade CE stages. Plot the high frequency response.
ter bypass capacitor	Discuss generally the fact that the capacitive reactance can be made to be negligible compared to the resistance. Indicate that the resistance includes the input circuit reflected through the transistor.
ium tube	Generally apply the principles developed above to the triode and the pentode amplifiers. Determine the Miller capacitance.
oupling	Discuss qualitatively the effect of RC decoupling filters.

h. Dbm	Define dbm as a reference.
C. Power amplifiers	Emphasize common
1. Harmonic distortion	Discuss nonlinea harmonic disto
2. Power output amplifier	Determine load l hyperbola.
	Discuss generall to a base curr using the inpu characteristic input circuit cuit. Discuss circuit nonlin how the input imize overall quantitative t
3. CE driver amplifier	Determine the dy stage to its d load in the an Introduce dire components.
4. Transformer coupling	Develop an under former to achi impedance load Stress the nee generally the on frequency r

	Define dbm as a power comparison with 1 milliwatt as a reference.
	Emphasize common emitter emplifier.
rtion	Discuss nonlinearity factors responsible for odd and even harmonic distortion.
mplifier	Determine load line using the maximum power dissipation hyperbola.
	Discuss generally the transfer of an input voltage signal to a base current signal and then to the output signal, using the input characteristic and the output transfer characteristic. Note the distortion contributed by the input circuit and that contributed by the output circuit. Discuss the cancelling effect that the output circuit nonlinearity has on the input circuit. Note how the input source resistance may be varied to minimize overall distortion. (See advanced section for quantitative treatment.)
ifier	Determine the dynamic load presented by a power amplifier stage to its driver stage. Include the effect of this load in the analysis and design of the driver stage. Introduce direct coupling to eliminate unnecessary components.
upling	Develop an understanding of the use of an output transformer to achieve maximum power transfer to a low impedance load. Determine the turns ratio required. Stress the need for matching impedance. Discuss generally the effect of transformer characteristics on frequency response and distortion.

5.	Distortion reduction	Discuss commer and the need
6.	Push-pull amplifiers	Develop a tran Note effect amplifier ba
7.	Phase inverters	Discuss the ne standard CE unity gain.
8.	Complementary symmetry	Discuss how a NPN transist high-efficie
9.	Inverse feedback	Discuss how n amplifier m percent fee Determine t distortion
		Use collector DC stabiliz
10.	Emitter follower	Discuss curre an output c

UCATION	
reduction	Discuss commercially acceptable distortion percentages, and the need to reduce harmonic distortion.
mplifiers	Develop a transfer characteristic for push-pull amplifiers. Note effect on even order harmonics. Discuss need for amplifier balance.
rters	Discuss the need for phase inversion, and the use of a standard CE amplifier to achieve phase inversion with unity gain.
ary symmetry	Discuss how a PNP transistor can be used to complement an NPN transistor to directly achieve low-distortion, high-efficiency, and low standby current.
edback	Discuss how noise and distortion introduced within an amplifier may be used to cancel itself out. Define percent feedback, db feedback, and feedback factor. Determine the gain with feedback and the percentage distortion with feedback.
	Use collector-to-base voltage feedback for both AC and DC stabilization of CE amplifier.
llower	Discuss current feedback. Apply the common collector as an output current amplifier.

ADVANCED ELECTRICITY OPTION

I. DC Generators 30
II. DC Motors 30
III. Alternators 31
IV. Three-Phase Systems 31
V. Transformer Principles 32
VI. Alternating Current Motors 33
VII. Relays 34

I. DC generators	
A. Construction and basic theory	Review generator co underlying the ge Consider the acti equation relating age.
1. Separately excited	
2. Self-excited (shunt)	
B. Factors affecting build-up	Discuss the factors excited shunt gen
C. Commutation	Discuss qualitative commutation and t
D. Characteristics of generators	
1. Magnetization curve	Briefly discuss the
2. External characteristics	Consider the extern pound generators, the change of te age regulation.
3. Voltage control	Discuss method for DC generators.
E. Losses and efficiency (shunt only)	Define copper and Discuss method o
II. DC motors	
A. Theory	Review the basic c torque in a DC m counter electrom relating termina

sic theory	Review generator construction and the basic concepts underlying the generation of a voltage in the armature. Consider the action of the commutator. Develop the equation relating terminal voltage and generated voltage.
ed unt)	
build-up	Discuss the factors affecting the build-up of a self-excited shunt generator.
	Discuss qualitatively the problems surrounding proper commutation and the need for interpoles.
generators	
rve	Briefly discuss the magnetization curve.
eristics	Consider the external characteristics of shunt and compound generators, and discuss the factors affecting the change of terminal voltage with load. Define voltage regulation.
	Discuss method for controlling the terminal voltage of DC generators.
ency (shunt only)	Define copper and rotational losses. Compute efficiency. Discuss method of measuring rotational losses.
	Review the basic concepts underlying the development of torque in a DC motor. Consider the generation of a counter electromotive force and develop the equation relating terminal voltage and CEMF.

B. Characteristics	Discuss the operati shunt, and compou and torque. List motors.
C. Starting requirements	Discuss basic start motors (four-poin ing resistor.
D. Operation	Discuss the operati motors. Consider trolling speed, a operation.
E. Losses and efficiency (shunt only)	Compute the efficie power output from
F. Automatic starters (general treatment)	Include electronic
III. Alternators	
A. Construction	Discuss the types o
B. General principles of operation	Discuss the generat frequency of spee
C. Applications	Consider the use of
D. Voltage regulation	Consider the effect lagging, and unit
IV. Three-phase systems	
A. Voltage, current, and power in the three-phase alternator	Review the advantag three-phase alter lation of power.

s	Discuss the operating characteristics of the DC series, shunt, and compound motors considering speed regulation and torque. List applications of the various types of motors.
rements	Discuss basic starting equipment and the starting of DC motors (four-point starting box). Compute value starting resistor.
	Discuss the operation of DC series, shunt, and compound motors. Consider reversing direction of rotation, controlling speed, and precautions to be observed in operation.
iciency (shunt only)	Compute the efficiency. Define losses. Compute horsepower output from the input and efficiency.
ters (general	Include electronic controls.
	Discuss the types of construction.
ples of operation	Discuss the generation of e.m.f. and show the effects on frequency of speed and number of poles.
	Consider the use of alternators in the electrical industry.
tion	Consider the effect on voltage regulation of leading, lagging, and unity power factor.
ems	
nt, and power in the alternator	Review the advantages of poly-phase systems. Develop the three-phase alternator. Present the formula for calculation of power.

1. Wye

2. Delta

B. Three-phase, four-wire transmission and distribution system.

Discuss this type co
transformers.

C. Measuring power in a three-phase system

Describe the advanta
the measurement of
wattmeter readings

D. Wye and delta loads (balanced)

Compute voltage, cur
for both resistive

V. Transformer principles

A. Transformer action

Review manner in whi
in power output.

B. Current and voltage

Define the term volt
directly proportio
inversely proporti

C. Polarities and connections

Discuss subtractive
polarity and volta
lying the parallel
phase, standard tr

1. Single-coil primary and secondary only

2. Two-coil primary and secondary (general treatment)

- Wye/wye
- Delta/wye
- Wye/delta
- Delta/delta
- Open delta

se, four-wire transmission tribution system.	Discuss this type connection as applied to generators and transformers.
power in a three-phase	Describe the advantages of the two-wattmeter method in the measurement of three-phase power. Discuss the wattmeter readings under resistive/reactive loads.
elta loads (balanced)	Compute voltage, current, power, and reactive voltamperes for both resistive and reactive loads (balanced only).
principles	
er action	Review manner in which the power input adjusts to changes in power output.
nd voltage	Define the term volt/turn. Explain that the voltages are directly proportional to turns ratio, and currents are inversely proportional to the turns ratio.
s and connections coil primary and secondary	Discuss subtractive and additive polarities. Consider polarity and voltage in discussing the concepts underlying the paralleling of transformers. Diagram three-phase, standard transformer connections: • Wye/wye • Delta/wye • Wye/delta • Delta/delta • Open delta (general treatment)
l primary and secondary ral treatment)	

D. Special types	
1. Instrument	Discuss the use of ins as part of control Discuss the current capacity, precision Demonstrate correct aspects of groundin secondary to become currents from a met
2. Current	Note: A possible enr the use of P the use of o power factor
3. Potential	Discuss the potential capacity, precision Demonstrate correct and the safety aspe culate line voltage and P.T. ratio. Ph standard markings (
E. Efficiency and losses	Compute the efficienc of determining iron hysteresis and eddy
VI. AC motors	
A. Three-phase induction	Discuss the construct the polyphase induc
1. Wound-rotor	speed, little maint
2. Squirrel-cage	principles of opera
3. Synchronous (general treatment)	magnetic field, tra the method of rever
4. Starting	maintenance.
5. Efficiency and horsepower output	Discuss the use of th induction motors.
6. Application	

Discuss the use of instrument transformers in measurement as part of control systems and as isolation devices. Discuss the current transformer (C.T.) as a low capacity, precision, current step down transformer. Demonstrate correct connections, and emphasize safety aspects of grounding. Emphasize danger in allowing secondary to become open-circuited. Calculate line currents from a meter reading.

Note: A possible enrichment for some classes might be the use of P.T. and C.T. with a voltmeter, and the use of obtained information in calculating power factor, and volt-ampere-reactive (vars).

Discuss the potential transformer (P.T.) as a low capacity, precision, voltage step-down transformer. Demonstrate correct connection to a high-voltage line, and the safety aspects of the grounded secondary. Calculate line voltage from secondary voltmeter reading and P.T. ratio. Phasing should involve correct use of standard markings (H and X) and dot.

Compute the efficiency from the losses. Discuss methods of determining iron and copper losses. Discuss hysteresis and eddy current losses.

Discuss the construction and important characteristics of the polyphase induction motor — essentially constant speed, little maintenance required. Develop the principles of operation, elaborating on the rotating magnetic field, transformer action, and slip. Mention the method of reversing direction of rotation. Discuss maintenance.

Discuss the use of the wound-rotor and squirrel-cage induction motors.

B. Single-phase

Demonstrate a
- Common
  Unive
  Split
  Shade
  Capac
  Synch
- Startin
- Starte
  Acros
  Wye/
  Compe
- Comput
  from

VII. Relays

A. Operation

Consider rel
- Basic
- Power
- Coil r

B. Characteristics (general treatment)

Discuss the
- Defini
- DC re
  Oper
  Mech
- AC re
  Pha
  Oper

C. Types (general treatment)

Discuss the

ICAL EDUCATION

e-phase

Demonstrate and discuss:

- Common types
  - Universal
  - Split-phase
  - Shaded pole
  - Capacitor-start
  - Synchronous
- Starting conditions
- Starters
  - Across-the-line
  - Wye/delta
  - Compensator
- Computation of efficiency and horsepower output, from input and output.

tion

Consider relays with regard to:

- Basic operation
- Power
- Coil ratings

cteristics (general treatment)

Discuss the operate and release times of relays:

- Definition
- DC relay
  - Operating times
  - Mechanical inertia
- AC relay
  - Phase displacement in magnetic flux
  - Operating times

s (general treatment)

Discuss the factors to consider in selecting a relay.

ADVANCED ELECTRONICS OPTION

I. Circuits 36

II. Communications Systems 38

III. Pulse Techniques 42

I. Circuits

A. Amplifiers

1. Wideband

Discuss
respo
respo

2. Tuned amplifiers

a. Parallel resonance and Q

Discus
a pa
impe
to a

b. Tuned RF amplifier

Develo
circ

3. Differential amplifier

Develo
effe
mode

4. Operational amplifier

Develo
need
impe
nega
and

B. Oscillators

Apply
achi
for
Arm
osc

ADVANCED ELECTRONICS OPTION

	Discuss factors affecting low-, mid-, and high-frequency response. Compute cutoff frequencies. Plot overall response.
ifiers	
resonance and Q	Discuss the variation with frequency of the impedance of a parallel circuit of pure R, L, and C. Calculate impedance and band width at resonance. Apply the above to a capacitor and a coil with its series resistance.
amplifier	Develop the TRF amplifier, using a parallel resonant circuit as the collector load.
al amplifier	Develop the differential amplifier to compensate for the effects of temperature changes and to eliminate common mode signals.
l amplifier	Develop a semiconductor operational amplifier. Note the need for high open-loop gain. Discuss the high input impedance characteristics of the amplifier with high negative feedback factor. Use it to add input signals and multiply signals by a constant.
	Apply positive feedback to a CE transistor amplifier to achieve oscillation. Determine the conditions necessary for oscillation. Illustrate this principle with simple Armstrong, Hartley, Colpitts, RC, and crystal-controlled oscillators.

C. Circuit analysis

1. Techniques

a. Signal tracing — Utilize signal t… Compute stage… voltage gain.

b. Circuit diagrams — Simplify practi… grams. Plot … priate. Disc… and impedance…

1. Schematic
2. Simplified schematic
3. Block

c. Power supply — Analyze DC powe… ripple reducti… stages.

2. Equipment performance — Develop an unde… including noi… accuracy, sen… cuit features… power require…

3. Applications — Apply the prece… control circu… semiconductor… sistor amplif…

a. Complete audio amplifier
b. Electronic voltmeter
c. Audio signal generator
d. Oscilloscopes
e. Superheterodyne receiver
f. Control circuits
g. Linear integrated circuits

ng

Utilize signal tracing techniques to analyze a circuit. Compute stage gains, attenuator losses, and overall voltage gain. Compute overall db gain.

rams

schematic

Simplify practical schematics and reduce to block diagrams. Plot input and output waveforms where appropriate. Discuss functional diagrams including control and impedance matching elements.

Analyze DC power distribution. Note methods used for ripple reduction and for signal decoupling between stages.

ormance

Develop an understanding of manufacturers' specifications including noise, distortion, frequency, response, accuracy, sensitivity, and selectivity. Discuss circuit features contributing to performance. Discuss power requirements.

Apply the preceding techniques to this equipment. Limit control circuits to simple temperature and photoelectric semiconductor transducers, feeding a single-stage transistor amplifier.

io amplifier

oltmeter

generator

s

yne receiver

uits

rated circuits

II. Communications systems	
A. AM transmitter circuit	Describe the oscillator,
	Show simple b the use of audio.
1. Operation	Describe the
2. Sidebands	Discuss the g distributio
3. Bandwidth	Show how the
4. Percentage modulation	Show how 100 students pe
5. Power distribution	Describe rela power. Ha
	based on:
B. FM transmitter	Develop the S/N ratio
1. Frequency deviation	Note that f_d ulating si
2. Bandwidth	Discuss the deviation
3. Basic FM transmitter	Show block d approach.
C. AM receiver	Draw the blo receiver a

ON

ems

rcuit

Describe the block diagram of a basic transmitter: oscillator, buffer, driver, PA, and modulator.

Show simple basic transistor modulation circuit. Discuss the use of the high-frequency carrier to transport the audio.

Describe the circuit operation.

Discuss the generation of sidebands and draw a spectrum distribution chart.

Show how the bandwidth is twice the frequency modulation.

lation

Show how 100 percent modulation is normal limit. Have students perform typical calculations.

ion

Describe relationship between carrier power and modulator power. Have students perform typical calculations based on: Power in one sideband = $\frac{M^2 \ Pc}{4}$.

Develop the need for frequency modulation because of its S/N ratio advantage over that of AM.

tion

Note that f_d is proportional to the amplitude of the modulating signal.

Discuss the bandwidth as being determined by frequency deviation and modulating frequency.

nitter

Show block diagram. Explain frequency multiplication approach.

Draw the block diagram of a typical AM superheterodyne receiver and show the waveforms present at each point.

1. RF amplifier	Explain that an RF a receiver to improv coverage of broadc
2. Convertor	Develop the concept the oscillator and
3. IF amplifier	Define the IF amplif gram. Show a typi its operation qual formers determine size that the IF a and selectivity of
4. Detector	Explain the operatio filter circuit.
5. Audio amplifier	
D. FM receiver	Draw block diagram o forms.
1. Detector circuit and operation	Show required respon Describe the circu
a. Foster Seeley	
b. Ratio detector	
2. Limiters	Describe the need fo cuit operation.
E. Transmission lines	Define a transmissio to carry electroma other. Discuss th

er	Explain that an RF amplifier is used in a superheterodyne receiver to improve S/N ratio and image rejection. Note coverage of broadcast band range, 550 — 1600 kilocycles.
	Develop the concept of heterodyning. Show the circuit of the oscillator and how its signal acts on the mixer.
er	Define the IF amplifier and locate it in the block diagram. Show a typical IF amplifier circuit and explain its operation qualitatively. Show how the IF transformers determine the amplifier response curve. Emphasize that the IF amplifier determined the sensitivity and selectivity of the receiver.
	Explain the operation of the detector as a rectifier and filter circuit.
ifier	
	Draw block diagram of FM receiver showing typical waveforms.
ircuit and operation	Show required response curve. Explain detection process. Describe the circuit operation by use of phasor diagrams.
eeley	
tector	
	Describe the need for the limiter circuit. Explain circuit operation.
lines	Define a transmission line as any pair of conductors used to carry electromagnetic energy from one place to another. Discuss the meaning of wavelength.

TECHNICAL EDUCATION

1.	Types of lines	Show and describ wire parallel their advantag circuits in lu
2.	Characteristic impedance	Define the chara as that impeda terminals of a particular typ
3.	Standing Wave Ratio	Demonstrate that of the same or signal handled
		Show that standi line is feedin characteristic
		Explain that Sta the maximum to voltage appear current to min
		Demonstrate that the line is fe characteristic
		Indicate that th term used in p and that an SW lems.
4.	Quarter-wave matching section	Discuss the quar required chara when given a s

TION

Show and describe the physical construction of the two-wire parallel and coaxial transmission lines. Compare their advantages and disadvantages. Show equivalent circuits in lumped constant form.

impedance

Define the characteristic impedance of a transmission line as that impedance which would be measured at the input terminals of an infinitely long transmission line of a particular type.

Ratio

Demonstrate that when the length of a transmission line is of the same order of magnitude as the wavelength of the signal handled, standing waves may appear on the line.

Show that standing waves do not exist on a line when the line is feeding a load whose impedance is equal to the characteristic impedance of the line.

Explain that Standing Wave Ratio (SWR) is the ratio of the maximum total RMS voltage to the minimum total RMS voltage appearing on the line. (Or maximum total RMS current to minimum total RMS current.)

Demonstrate that standing waves appear on the line when the line is feeding a load which is not matched to the characteristic impedance of the line.

Indicate that the Standing Wave Ratio is the most common term used in practice for discussing line performance, and that an SWR of 1:1 is most desirable. Solve problems.

matching section

Discuss the quarter-wave matching section. Determine the required characteristic impedance of a matching section when given a source impedance and load impedance.

F. Antennas

Indicate that when a high-
a conductor, a power los
accounted for by the sin

Explain that attempts at a
simple magnetic coupling
and magnitudes involved
losses continue even if
is available **to** absorb

Explain that this loss is

Emphasize that this elect
mized by separating the
that they are at right a

1. Half-wave dipole (Hertz)

The antenna thus created
the most basic of antenn
as a Hertz antenna.

Explain that the length o
wave length of the signa

Point out that the same a
transmission and recept

2. Quarter-wave (Marconi)

Discuss the quarter-wave
known as a Marconi ante

Show that the Marconi ant
special case of vertica
the antenna appearing a

3. Directors

Define a director as an e
antenna in front of the
tion of desired radiati
ing the directivity of

Indicate that when a high-frequency current passes through a conductor, a power loss takes place which cannot be accounted for by the simple $P = I^2R$ formula.

Explain that attempts at attributing this phenomenon to simple magnetic coupling are precluded by the distances and magnitudes involved as well as the fact that the losses continue even if no receptor (second conductor) is available to absorb the energy.

Explain that this loss is due to electromagnetic radiation.

Emphasize that this electromagnetic radiation can be maximized by separating the ends of a transmission line so that they are at right angles to the transmission line.

ole (Hertz)

The antenna thus created is known as a dipole antenna, the most basic of antennas. The dipole is also known as a Hertz antenna.

Explain that the length of the dipole is one-half the wave length of the signal being transmitted or received.

Point out that the same antenna can be used for both transmission and reception.

(Marconi)

Discuss the quarter-wave vertical antenna. This is also known as a Marconi antenna.

Show that the Marconi antenna can be explained as a special case of vertical dipole, the second half of the antenna appearing as a reflection in the ground.

Define a director as an element added to the basic dipole antenna in front of the dipole (front being the direction of desired radiation), for the purpose of increasing the directivity of the antenna.

4. Reflectors	Define a reflector dipole antenna be direction of unde increasing the di
G. TV receivers and transmitters	(General treatment
III. Pulse techniques	Develop as an intro amplification, a with application
A. Pulse characteristics (ideal rectangular pulse)	Define leading edg ing period, puls rate, and duty c
	Discuss the depend cycle, and the a distortionless a
B. RC circuit response	Apply a rectangula the effect on ri domain, and the in the frequency
	Define and calcula
C. Integrators and sweep generator	Examine the respon tangular pulse i creased. Develo Apply as a sweep
D. Differentiation	Examine the respon rectangular pul decreased. Dev case.

UCATION

	Define a reflector as an element added to the basic dipole antenna behind the dipole (behind being the direction of undesired radiation), for the purpose of increasing the directivity of an antenna.
and transmitters	(General treatment *only*)
es	Develop as an introduction, the characteristics, shaping, amplification, and generation of transient signals, with application to modern fields of electronics.
teristics (ideal r pulse)	Define leading edge, trailing edge, pulse duration, resting period, pulse repetition time, pulse repetition rate, and duty cycle.
	Discuss the dependence of pulse harmonic content on duty cycle, and the amplifier characteristics required for distortionless amplification.
esponse	Apply a rectangular pulse signal to RC filters and observe the effect on rise time, tilt, and fall time in the time domain, and the corresponding attenuation of harmonics in the frequency domain.
	Define and calculate rise time, tilt, and fall time.
and sweep generator	Examine the response of a low-pass RC network to a rectangular pulse input as the RC time constant is increased. Develop the integrator as the limiting case. Apply as a sweep generator.
tion	Examine the response of a high-pass RC network to a rectangular pulse input as the RC time constant is decreased. Develop the differentiation as the limiting case.

E.	Pulse amplifiers	Apply the analyses o waves to measure t amplifier, and to pulses.
F.	Limiters and clippers	Apply the semiconduc forward voltage. circuits.
G.	Clamping circuits and voltage doubler	Stress the property voltage. Develop circuits. Apply t
H.	Transistor as a switch	Introduce use of the age and current co off (off). Determ action. Apply as
I.	Bistable multivibrator	Connect two transist pare second stage bistable multivibr
J.	Counting circuits	Use several bistable circuit.
K.	Time delay switch	Add RC circuit to tr
L.	Astable multivibrator and pulse generator	Cascade two time-del vibrator. Generat
M.	Applications	Relate the preceding radar (range prob separation, vertic blanking pulses),

plifiers	Apply the analyses outline above to the use of square waves to measure the frequency response of an audio amplifier, and to the amplification of rectangular pulses.
and clippers	Apply the semiconductor diode as an electronic switch at forward voltage. Develop limiting and clipping circuits.
circuits and voltage r	Stress the property of capacitors to oppose a change in voltage. Develop both positive and negative clamping circuits. Apply to half-wave voltage doubler.
or as a switch	Introduce use of the transistor as a switch. Study voltage and current conditions at saturation (on) and cut-off (off). Determine condition necessary for switching action. Apply as a slicer and as a gate.
multivibrator	Connect two transistor switch circuits in cascade. Compare second stage output with first stage input. Form bistable multivibrator. Develop input signal circuit.
circuits	Use several bistable multivibrators to form a counting circuit.
ay switch	Add RC circuit to transistor switch to provide delay.
multivibrator and pulse tor	Cascade two time-delay circuits to form an astable multivibrator. Generate pulses of varied width.
ions	Relate the preceding techniques in a general manner, to radar (range problems), television (sync pulse, sync separation, vertical sweep, horizontal sweep, and blanking pulses), and to simple computer circuits.

COMPUTER CIRCUITRY OPTION

I. Number Systems 46
II. Logic Functions 46
III. Logic Design 47
IV. Diode Logic Circuits 47
V. Transistor Logic Circuits 48
VI. Pulses and Pulse Trains 48
VII. Pulse Circuitry 48
VIII. Computer Circuits 49
IX. Computer Systems 50

I. Number systems

A. Binary system

B. Octal

C. Hexadecimal

D. Codes

Explain th
number s

Demonstrat
facility
Addition
understo

Demonstrat

Demonstrat

Explain t
Explain
binary
tion Gr

II. Logic functions

A. Binary variables

1. Definition

Define a
ations

2. Functions

Explain t
binary
be repr

B. Logic blocks

1. AND
2. OR
3. INVERTOR
4. NAND
5. NOR

Explain t
Present
functi
for in
of com
order
relati
combin

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ons

iables

on

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ks

COMPUTER CIRCUITRY

Explain the construction of a positional significance number system, as demonstrated by the decimal system.

Demonstrate the binary number system. Develop student facility in conversion to and from the decimal system. Addition and subtraction in the binary system should be understood.

Demonstrate the octal number system.

Demonstrate the hexadecimal number system.

Explain the difference between a code and a number system. Explain the BCD code as a four-bit, column-by-column, binary representation of decimal digits. Briefly mention Gray Code.

Define a binary variable and describe conditions and situations which they may represent.

Explain the concept of a function dependent upon several binary variables. Show that the function itself must be representable as a binary variable.

Explain the logic function performed by each logic block. Present logic symbols used to represent each of these functions. Introduce the Truth Table as a technique for investigating logic functions. Stress the listing of combinations of variables in ascending numerical order to insure inclusion of all combinations. Show relationship between number of variables and number of combinations.

III. Logic design	Mention areas in which simple examples. Di circuit design.
A. Boolean algebra	Define Boolean algebra reducing equations i
1. Theorems and postulates	State and prove the th algebra.
2. Equation reduction	Assign problems in bin algebra.
B. Karnough map	Explain that the Karno the reduction of bin map for two, three, reductions are made. in "standard sum for equations from a Kar
C. Truth Table	Show how to use a Trut from the statement o Truth Table in provi
IV. Diode logic circuits	Analyze two input and stantaneous voltage
A. AND gate	function. Stress th
B. OR gate	voltage levels corre plain that positive determined by select
C. Matrices	Explain format of diod binary numbers. Sho for coding and decod

COMPUTER CIRCUITRY

Mention areas in which logic design is used and give simple examples. Distinguish between logic design and circuit design.

Define Boolean algebra as a mathematical technique for reducing equations involving binary variables.

State and prove the theorems and postulates of Boolean algebra.

Assign problems in binary equation reduction using Boolean algebra.

Explain that the Karnough map is a device for simplifying the reduction of binary equations. Present the Karnough map for two, three, and four variables and explain how reductions are made. Plot the map for binary equations in "standard sum form" and write "standard sum form" equations from a Karnough map.

Show how to use a Truth Table to develop a binary equation from the statement of the problem. Show importance of Truth Table in proving validity of reduction.

Analyze two input and three input gates in terms of instantaneous voltage levels, bias conditions, and logic function. Stress the existance of only two discreet voltage levels corresponding to "one" and "zero." Explain that positive or negative logic may be used, determined by selection of voltage level.

Explain format of diode matrix for converting decimal to binary numbers. Show that this technique can be used for coding and decoding.

V. Transistor logic circuits

A. Invertor

Review phase inve
and explain its
duce clamp volt

B. Diode transistor logic

Develop on DTL NA
OR, and Inverto
logic blocks wh
gates. Show in
multiple NOR IC

1. NAND

2. NOR

C. Other

Present "Resistor
Transistor-Logi
NAND, NOR, and

1. RTL

2. DCTL

3. CML

VI. Pulses and pulse trains

A. The ideal pulse

Define and explai
pulse and pulse
Demonstrate eff
gates. Explain

B. The distorted pulse

VII. Pulse circuitry

A. Bistable multivibrator

Explain the opera
its function i
capacitor pulse
evolve at J-K
niques and wave

its

Review phase inversion in the common emitter amplifier and explain its effect on logic voltage levels. Introduce clamp voltage to reduce forbidden zone.

ogic

Develop on DTL NAND and NOR gates as combinations of AND, OR, and Invertor. Explain that NAND and NOR are basic logic blocks which may be used to construct OR and AND gates. Show interconnections necessary to convert multiple NOR IC to OR and AND.

Present "Resistor-Transistor-Logic," "Direct-Coupled-Transistor-Logic," and "Current-Mode-Logic" forms of NAND, NOR, and Invertor.

ins

Define and explain the terms used to describe an ideal pulse and pulse train. Define rise time and fall time. Demonstrate effect of distorted pulse on AND and OR gates. Explain need for delay lines.

se

rator

Explain the operation of the saturated "Flip-Flop" and its function in logic circuits. Develop resistor capacitor pulse generating and diode pulse steering to evolve at J-K "Flip-Flop." Emphasize trigger techniques and waveshapes.

B. Astable multivibrator	Explain the astabl pulses. Show how rate from feedbac Flops can be used
C. Monostable multivibrator	Discuss the need fo at a specific tim vibrator as the c it is half of ast how to calculate pulse train devel train.
D. Schmitt trigger	Explain the operati shaping as in tap
VIII. Computer circuits	
A. Adders	Review binary addit sum and carry of draw the logic bl implement the dia IC's. Repeat for
1. Half	
2. Full	
B. Subtractors	Repeat the procedur
1. Half	
2. Full	
C. Shift register	Review the "steered interconnected f right (division) shift registers onstrate applicat

COMPUTER CIRCUITRY

itor

Explain the astable multivibrator as a source of clock pulses. Show how to determine pulse width and pulse rate from feedback network. Show how "steered" Flip-Flops can be used for frequency division.

brator

Discuss the need for an accurately timed pulse occurring at a specific time, and introduce the monostable multivibrator as the circuit to accomplish this. Show that it is half of astable and half of bistable. Explain how to calculate ON and OFF times. Show the output pulse train developed in response to an input pulse train.

Explain the operation of the Schmitt trigger in pulse shaping as in tape-read circuits.

Review binary addition. Develop a Truth Table for the sum and carry of a one-bit binary adder. Have students draw the logic block diagram from the Truth Table, and implement the diagram using discreet components and IC's. Repeat for full-adder.

Repeat the procedure for subtraction.

Review the "steered" Flip-Flops and show how they may be interconnected for shift left (multiplication) or shift right (division) registers. Explain the function of shift registers as buffering devices for memory. Demonstrate applications of IC's.

D.	Counters	Show how ' operate the func specifi to reset
E.	Sign comparator	Review ari duce "ba circuits and show
IX.	Computer systems	
A.	Block diagram	Develop a input, c
B.	Input/output devices	Discuss th porary
C.	Memory	Review mag of drums
D.	Control	Discuss th lines. of "more the con periphe
E.	Troubleshooting techniques	Discuss th oscillo

EDUCATION

	Show how "steered" Flip-Flops may be interconnected to operate as counters (count-up and count-down). Explain the function of counters in initiating action after a specific time. Show how AND and OR gates can be used to reset counters.
urator	Review arithmetic operations with signed numbers. Introduce "base-minus-one" complement to avoid subtractor circuits. Develop logic circuit for sign comparator and show interconnections with two-bit full-adder.
stems	
gram	Develop a simplified block diagram of a computer showing input, output, control, memory, and arithmetic sections.
ut devices	Discuss the characteristics and applications of contemporary input/output devices.
	Review magnetics and discuss the principles of operation of drums, discs, and cores.
	Discuss the importance of timing and the need for delay lines. Explain the concept of decision-making in terms of "more than," "less than," or "equal to." Introduce the concepts of a "central-processing-unit" and of peripheral equipment.
ooting techniques	Discuss the purpose of diagnostic routines. Show how the oscilloscope can be used for pulse train analysis.

ELECTRICAL CONSTRUCTION

I. Safety 52

II. Basic Hand Skills 52

III. Construction 52

IV. Residential and Power Wiring 52

ELECTRICAL CONSTRUCTIO

I. Safety	Discuss gen cautionary artificia
II. Basic hand skills	Students wi acceptabl niques cu industry.
A. Hand tools B. Drilling tools C. Measuring tools D. Soldering tools	The basic s lacing, d crimping, gauges wi
III. Construction	The constru of all st
A. Layout B. Wiring C. Testing D. Reporting	type expe basic mec cover lay writing c ing famil tion manu
IV. Residential and power wiring (general treatment)	Attention w residenti of the sk ing basi and condu
	All studen National

Note: The desirable work skills may be taught in several ways, taught as a separate "shop" subject, or integrated int skills could be taught in a machine shop course; the p or electronic laboratory.

ELECTRICAL CONSTRUCTION

Discuss general shop and field safety, considering precautionary measures and first aid. Eye safety and artificial respiration techniques should be included.

ills

Students will be required to demonstrate a commercially acceptable degree of proficiency with tools and techniques currently used in the electricity and electronics industry.

ools

tools

tools

The basic skills will include wire stripping, soldering, lacing, drilling, tapping, reaming, filing, grinding, crimping, and splicing. Use of the micrometer and wire gauges will be taught.

The construction of a project or projects will be required of all students, in order to develop practical, work-type experiences and to demonstrate ability to apply basic mechanical skills. The scope of this work will cover layout, wiring, testing, troubleshooting, and writing of a report. Time should be devoted to becoming familiar with catalogs and test equipment instruction manuals.

nd power wiring
eatment)

Attention will be given to the fundamental principles of residential and industrial wiring, and to development of the skills (manual and mental) important in performing basic wiring jobs involving the use of armored cable and conduit.

All students will be required to be familiar with the National Electric Code and local wiring codes.

able work skills may be taught in several ways, depending on local conditions. They may be as a separate "shop" subject, or integrated into other courses. For example, the basic hand could be taught in a machine shop course; the project could be accomplished in an electrical tronic laboratory.

ELECTRICAL-ELECTRONIC DRAFTING

I. Conventions, Symbols, and Standards 54
II. Lettering 54
III. Use and Care of Drafting Instruments and Materials 54
IV. Measuring and Measuring Instruments 54
V. Dimensioning 55
VI. Notes 55
VII. Orthographic Projection 56
VIII. Block Diagram 56
IX. Electronic Symbols and Conventions 56
X. Schematic Layout Procedure 57
XI. Schematic Diagrams 57
XII. Chassis and Enclosures 57
XIII. Chassis Assemblies 58

I. Conventions, symbols, and standards	Introduction, a
A. Layout of sheet	
B. Terminology	
C. Alphabet of lines	
II. Lettering	Emphasize impo especially f used in lett lines, and t electronics
A. Style	
B. Technique	
III. Use and care of drafting instruments and materials	Emphasize the dimensional proper point and types. compass and books as aid drafting sh
A. T-square, parallel straightedge, and board	
B. Triangles	
C. Pencils	
D. Paper	
E. Instruments	
F. Special devices	
G. References and handbooks	
IV. Measuring, and measuring instruments	
A. Engineer's scale	Measuring dev a scale. U

ELECTRICAL-ELECTRONIC DRAFTING

symbols, and standards	Introduction, and familiarization with terminology.
sheet	
gy	
of lines	
	Emphasize importance of proper lettering legibility, especially for photo-reduction. Demonstrate techniques used in lettering and their purpose, the use of guide-lines, and the style of lettering recommended by the electronics industry.
e of drafting instruments ials	Emphasize the importance of "squareness" in maintaining dimensional stability. Discuss the selection of pencil, proper pointing techniques, and standard paper sizes and types. The use of drafting instruments, especially compass and dividers, and of templates and reference books as aids to the proper execution of electronic drafting should be emphasized.
parallel straightedge, rd	
ts	
levices	
s and handbooks	
nd measuring instruments	
s scale	Measuring devices. Using the Engineer's scale. Reading a scale. Using the micrometer.

B. Combination scale		Emphasize the critical i those dimensions neces
C. Calipers		
D. Dividers		
E. Mechanical aids		
F. Radius gauge		
G. Protractor bevel		
H. Micrometer		
V. Dimensioning		
A. Units		Standard methods of dime curacy. Techniques us
B. Lines		centerline. Arrowhead
C. Arrowheads		
D. Methods		
E. Angles and arcs		
VI. Notes		
A. Material		The function of notes.
B. Number required		ing. Modification ind tion methods of compon
C. Trade terms		
D. Title block		

DRAFTING

Emphasize the critical importance of measuring accurately those dimensions necessary to reproducibility.

Standard methods of dimensioning. Importance of accuracy. Techniques used in dimensioning, base line, centerline. Arrowhead practice.

The function of notes. Methods of placing notes on drawing. Modification indication. EIA and MIL specification methods of component and diagram numbering.

TECHNICAL EDUCATION

VII. Orthographic projection

A. Relationship of views

B. Selection of views

1. Necessary views

2. Choosing location on plate

VIII. Block diagram

A. Block layout

1. Inline layout

2. Row layout

3. Complex layout

4. Columns and rows

5. Line work

B. Flow path

C. Block size

D. Graphical symbols

IX. Electronic symbols and conventions

A. Resistors

B. Capacitors

C. Inductors and transformers

DUCATION

rojection

p of views

f views

views

location on plate

t

yout

t

ayout

nd rows

ymbols

ols and conventions

nd transformers

The orthographic projection as an introduction to pictorial diagrams. Transferring information from view to view. Selection of views to best display the object.

The role of the block diagram in electronic drafting. The use of the block diagram in electronic troubleshooting. Military specifications for block diagrams.

Standard and special (EIA and military) electronic symbols. Color codes. Pictorial representation. Pin numbering and base diagrams for tubes and transistors.

D. Electron tubes	
E. Semiconductor devices	
X. Schematic layout procedure	
A. Data	Decisions to be mad size. Determinat
B. Trial layout	for eye appeal.
C. Estimating dimensions	
D. Symbol locations	
E. Note selection	
XI. Schematic diagrams	All phases of elect taught and practi to accompany thei tion projects in Heavy emphasis o symbols.
XII. Chassis and enclosures	Emphasis to be pla drawings needed equipment. Stud of drawings for
A. Types	
B. Layout	Human factors in p
	Hole size and moun components.
	Degree of toleranc
C. Marking	Chassis marking. Prototype markin Use of dry lette

DRAFTING

levices

rocedure

ensions

ns

s

osures

Decisions to be made before drafting. Selection of paper size. Determination of spacing. Techniques of layout for eye appeal. Determination of need for notes.

All phases of electronic schematic diagrams will be taught and practiced. Students will prepare diagrams to accompany their laboratory experiments and construction projects in addition to other assigned plates. Heavy emphasis on layout, linework, lettering, and symbols.

Emphasis to be placed on the development of all working drawings needed to manufacture a piece of electronic equipment. Students will be required to develop a set of drawings for one of their construction projects.

Human factors in panel layout.

Hole size and mounting methods for all common electronic components.

Degree of tolerance and its effect on cost of manufacture.

Chassis marking. Standard abbreviations. Warning labels. Prototype markings as opposed to production markings. Use of dry lettering kits.

XIII. Chassis assemblies

A. Pictorial drawing — Relation of subassembl equipment. Standar

B. Assembly — Selection of chassis

C. Panel drawing — Panel drawings for ma

Note: The basic drafting skills may be taught in various ways, depending and its facilities. For example, most of the skills could be taug while the application to the electrical-electronic field could be

Relation of subassemblies to the overall piece of equipment. Standards for subassembly designations.

Selection of chassis breakdown.

Panel drawings for manufacturing.

skills may be taught in various ways, depending on the organization of the school
For example, most of the skills could be taught in a mechanical drawing course,
on to the electrical-electronic field could be integrated in other subjects.

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